

S. J. P. 1
E. J. P. 1
C. M. 1

in the case of the ion-exchange resin product being a cylinder with the metal electrode formed on an outer or inner surface thereof, the ratio of the thickness (a2) of the metal electrode formed on the ion-exchange resin product to the thickness (b2) of the cylindrical ion-exchange resin product including the metal electrode ($a2/b2$) is in the range of 0.02 to 0.70,

in the case of the ion-exchange resin product being a cylinder with the metal electrode formed on both an inner and outer surface thereof, the ratio of the thickness (C) of the cylindrical ion-exchange resin product excluding the metal electrode to the thickness (b4) of the cylindrical ion-exchange resin product including the metal electrode ($C/b4$) is in the range of 0.20 to 0.95.

REMARKS

The application has been amended. In particular, claim 1 has been amended to include specific limitations regarding the thickness of the metal electrode formed on the ion-exchange resin product. Support for this amendment can be found in the application as filed on page 14, line 22 through page 17, line 7. As such, the amendment is not considered new matter within the meaning of 35 USC §132. In view of the amendments above and the remarks below, entry of the amendment and reconsideration is respectfully requested.

Claim 1 is rejected under 35 USC § 103(a) as being unpatentable over PCT Publication No. WO 97/26039 to Shahinpoor et al. (hereinafter "Shahinpoor"), alone or in combination with U.S. Patent No. 4,364,803 to Nidola et al. (hereinafter "Nidola"). This rejection is respectfully traversed.

The present invention is directed to a process for producing an actuator element involving forming metal electrodes on an ion-exchange resin through repeatedly conducting the steps of adsorption, deposition, and washing for a period of 4 to 9 cycles. By repeatedly conducting the steps of adsorption, deposition, and washing, metal deposition

further proceeds to the interior of the ion-exchange resin product, which increases the contact area between the ion-exchange resin product and the metal electrode, thereby increasing the quantity of ions migrating to the electrode and increasing the thickness of the metal electrode. Moreover, the claimed thickness of the metal electrode reduces the surface resistance of the electrode and improves the conductivity thereof, and further results in a high degree of bending (deformation or degree of displacement), therefore exhibiting quick response as an actuator element. The Shahinpoor and Nidola references fail to disclose repeating the adsorption, deposition, and washing steps from 4 to 9 times, and fail to teach the specific thickness ratios as recited in the present claims. Moreover, nothing in either of these references, whether considered alone or in combination, discloses that improved bending or deformation can be achieved through such repeated processing steps to achieve the claimed thickness ratios.

To the contrary, Shahinpoor merely discloses a method for creating an actuator through chemical reduction on an ion-exchange material. Nothing in Shahinpoor teaches or suggests repeating steps of adsorbing a metal complex, reducing the metal complex for deposition, and washing the ion-exchange resin having the deposited metal.

In order to overcome these deficiencies, the Examiner has cited the Nidola reference, indicating that Nidola teaches controlling the amount of metal deposited on the surface of ion-exchange resins during reductive deposition. The Examiner concludes that it would have been obvious to repeat the step of allowing an ion-exchange resin to adsorb a metal complex because it is generally known to regulate the amount of metal deposited by controlling parameters, including the number of cycles.

Nidola is directed to deposition of electrodes on ion-exchange membranes, which deposition process involves a presorbed amphoteric compound to improve deposition of a metal layer on the membrane. Nothing in the Nidola reference, however, discloses that a

higher degree of bending or deformation, namely a degree of displacement, can be achieved by increasing the contact area between the ion-exchange resin-product and the metal electrode through repeating the number of cycles of adsorption, deposition, and washing, thereby increasing the thickness of the metal electrode as claimed in the present application.

In fact, Nidola fails to address the degree of bending or deformation of actuators. While Nidola indicates that certain operations of the process can be repeated to deposit a desired metal thickness, Nidola fails to indicate in any way how repeatedly conducting adsorption, deposition, and washing for a period of 4 to 9 cycles can increase the thickness, and thereby improve the bending or deformation characteristics of a polymeric actuator. To the contrary, an increased thickness of the electrode would lead one to believe that the degree of bending or deformation would be reduced.

As noted, nothing in Shahinpoor teaches or suggests repeating the steps of adsorbing a metal complex, reducing the metal complex for deposition, and washing the ion-exchange resin having the deposited metal. Moreover, the combination of Nidola with the Shahinpoor reference fails to teach repeatedly conducting such steps for a cycle of 4 to 9 times to achieve the optimum properties as set forth through examples 1-9 and comparative example 1 of the present application. Furthermore, nothing in either the Shahinpoor or Nidola references teaches the specific thickness ratios as set forth in the present claims. In fact, since Shahinpoor merely discloses deposition of an electrode through a single cycle, the thickness of Shahinpoor is too thin to expect any high amount of displacement or deformation, particularly in view of the bending or deformation achieved through the present invention. Furthermore, Nidola fails in any way to address bending or deformation characteristics.

Accordingly, none of the prior art references disclose or suggest the process of the present invention, which involves repeatedly conducting the steps of adsorption,

deposition, and washing for a cycle of 4 to 9 times, let alone such a process which results in an ion-exchange resin product having a metal electrode thickness ratio as claimed in the present invention. Accordingly, the rejection of claim 1 based on the combination of these references is improper. Withdrawal of the rejection based on these references is therefore respectfully requested.

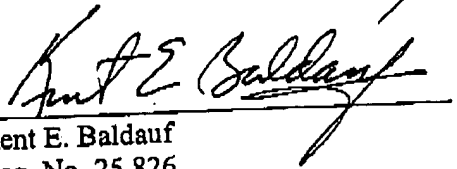
In view of the above remarks, entry of the amendment, reconsideration and withdrawal of the rejection and favorable reconsideration are respectfully solicited. Applicants also respectfully request that any further action by the Examiner be issued on an expedited basis, as the present response is being filed at the three-month date for response to the final Action.

Should the Examiner have any questions regarding any of this information, the Examiner is invited to contact Applicants' undersigned representative by telephone at 412-471-8815.

Respectfully submitted,

WEBB ZIESENHEIM LOGSDON
ORKIN & HANSON, P.C.

By


Kent E. Baldauf
Reg. No. 25,826
Attorney for Applicants
700 Koppers Building
436 Seventh Avenue
Pittsburgh, PA 15219-1818
Telephone: (412) 471-8815
Facsimile: (412) 471-4094

Serial No. 09/253,638
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MARKED-UP VERSION OF THE CLAIM

1. (Twice Amended) A process for producing a polymeric actuator comprising an ion-exchange resin product and metal electrodes which are formed on the surface of the ion-exchange resin product and are insulated from each other, said actuator operating as an actuator by applying a potential difference between the metal electrodes when the ion-exchange resin product is in the water-containing state to allow the ion-exchange resin product to undergo bending or deformation,

wherein the following steps (i) to (iii) are repeatedly conducted to form the metal electrodes ranging from the surface of the ion-exchange resin product to the inside thereof;

(i) a step of allowing the ion-exchange resin product to adsorb a metal complex in an aqueous solution (adsorption step),

(ii) a step of reducing the metal complex adsorbed on the ion-exchange resin product by a reducing agent to deposit a metal on the surface of the ion-exchange resin product (deposition step), and

(iii) a step of washing the ion-exchange resin product having the deposited metal (washing step),

the number of cycles of the above steps is in the range of 4 to 9[.] ; wherein
in the case of an ion-exchange resin product being a plate or a film, the ratio of
the thickness (a1) of the metal electrode formed on the ion-exchange resin product to the
thickness (b1) of the ion-exchange resin product including the metal electrode (a1/b1) is in
the range of 0.03 to 0.40.

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in the case of the ion-exchange resin product being a cylinder with the metal electrode formed on an outer or inner surface thereof, the ratio of the thickness (a2) of the metal electrode formed on the ion-exchange resin product to the thickness (b2) of the cylindrical ion-exchange resin product including the metal electrode (a2/b2) is in the range of 0.02 to 0.70.

in the case of the ion-exchange resin product being a cylinder with the metal electrode formed on both an inner and outer surface thereof, the ratio of the thickness (C) of the cylindrical ion-exchange resin product excluding the metal electrode to the thickness (b4) of the cylindrical ion-exchange resin product including the metal electrode (C/b4) is in the range of 0.20 to 0.95.